崇新学堂

2024 — 2025 学年第一学期

实验报告

课程名称：Introduction to EECS Lab

实验名称：DL7 – For Your Eyes Only

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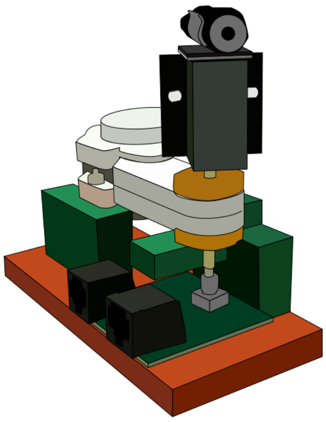
DL7: For Your Eyes Only

1. Introduction

The objective of the upcoming labs is to construct a robot "head" equipped with light-detecting "eyes" and a neck capable of tracking the light. Today's tasks include simulating and experimenting with basic circuits, exploring voltage dividers and potentiometers, and using photoresistors to build a light sensor circuit for the robot head.



The Robot's Head

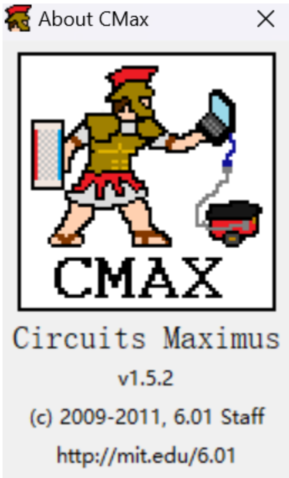
2. Experimental step

Step 1: Configure the Proto Board

We connect the +15V and GND terminals of the power supply to the power rails of our proto board using alligator clips and short wires. We attach the alligator clip to the power supply terminal by placing one jaw into the terminal center without unscrewing it. We set the multimeter to measure voltage and connect its probes to the proto board power rails using alligator clips and short wires. We turn on the power supply and measure the voltage with the multimeter, adjusting the positive supply to +10V to ensure proper voltage delivery to our proto board.

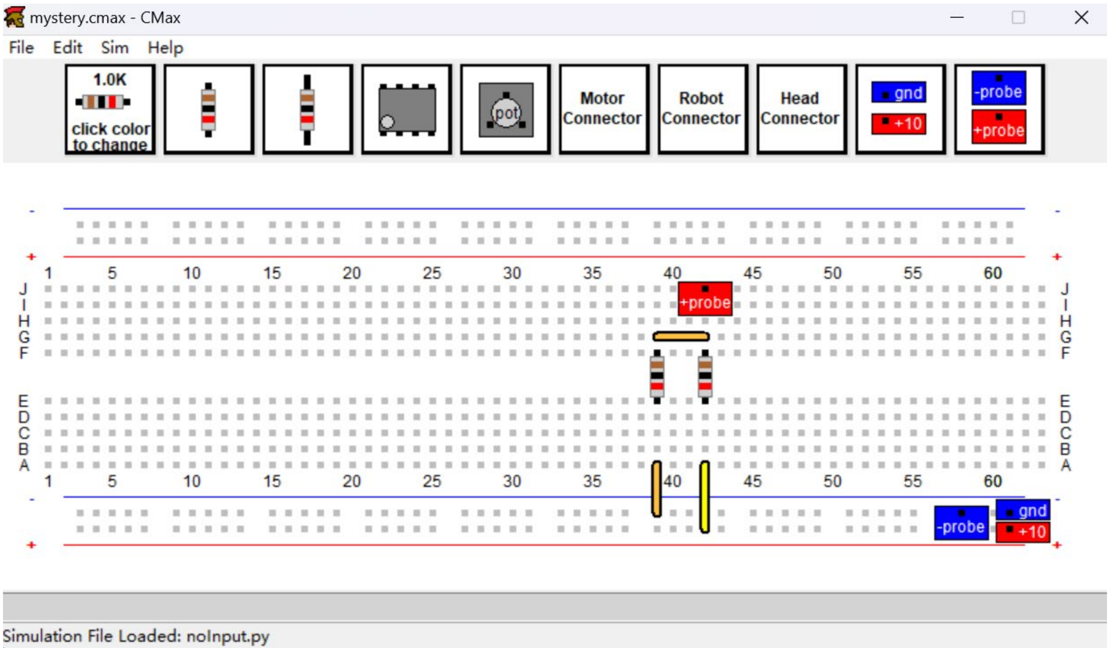
Step 2: Check the version of CMax

As shown in the figure, we can see that the version of CMax is v1.5.2.



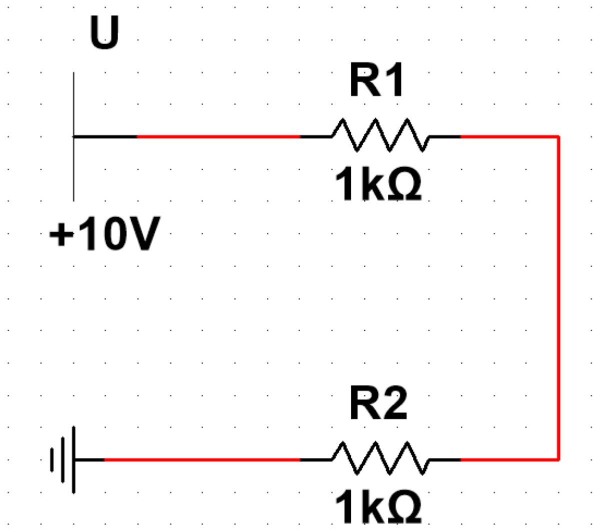
Step 3: Open mystery.cmax

After opening mystery.cmax, the CMax page is as follows.



Step 4:Draw a schematic diagram for the circuit shown in the CMax window.

The relevant schematic diagram is as follows.



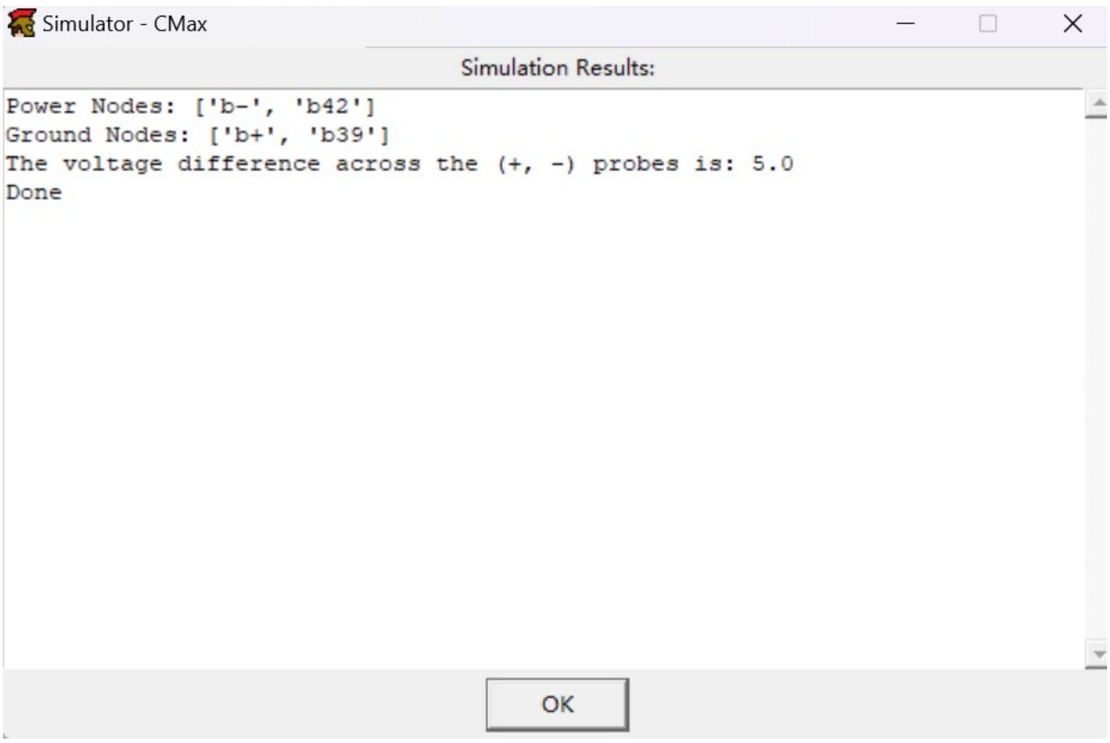
Step 5:Predict the voltage that will be measured across those two nodes in the circuit.

According to Ohm's Law:

$$I = \frac{U}{R_1 + R_2} = \frac{10V}{1k\Omega + 1k\Omega} = 5mA$$

$$U = IR_2 = 5mA \times 1k\Omega = 5V$$

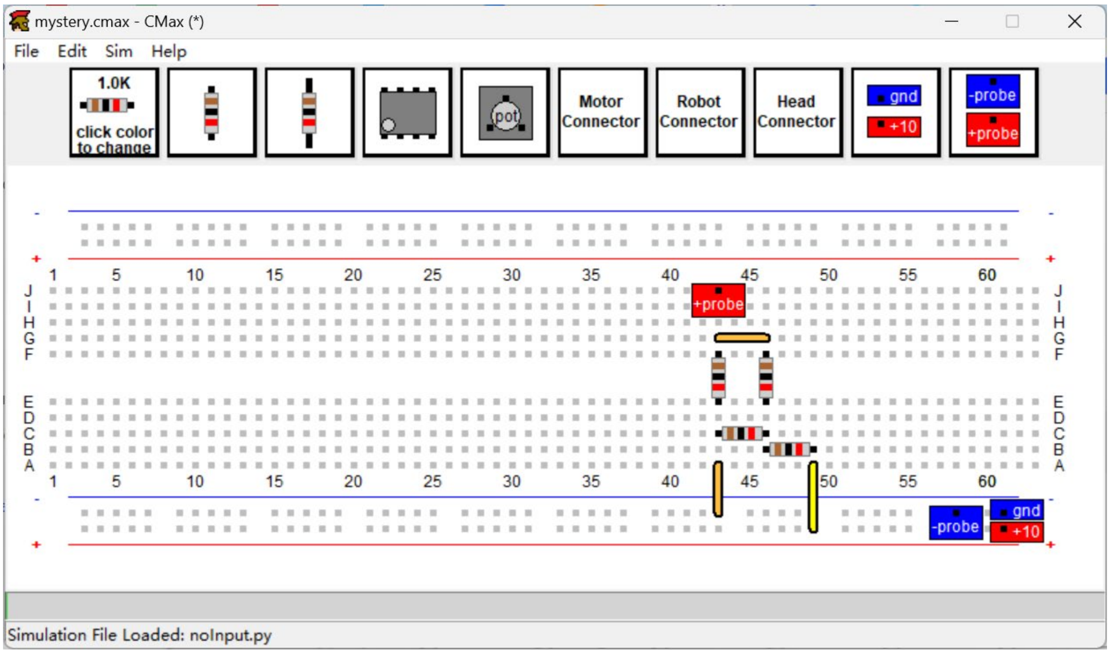
Step 6: Make the simulator calculate the voltage across the probes.



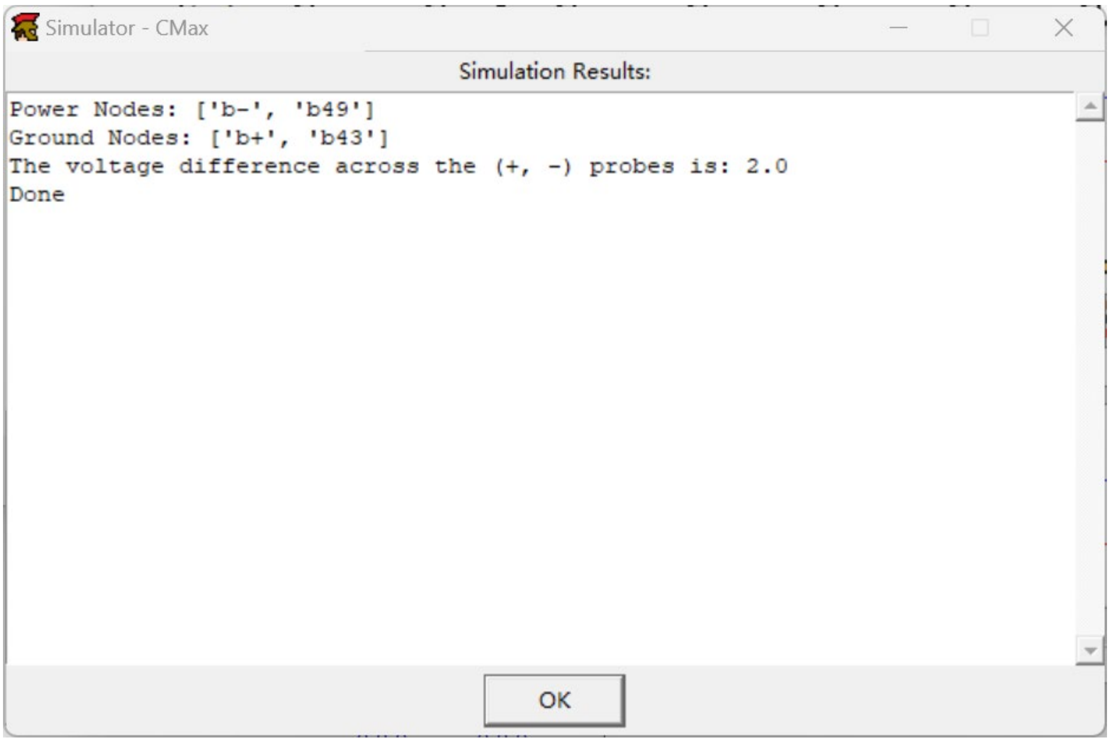
From this, we can know that the calculated results are consistent with the simulated results.

Step 7: Lay out this circuit using CMax

A voltage divider is a circuit that uses resistors to generate an output voltage that is a fixed fraction of the input voltage.The lab-guide requires us to cascade two divide-by-two circuits to produce a divide-by-four circuit. We lay out this circuit using CMax.



We connected the “probes” so that they measure Vo. The simulated value of Vo is in the pop-up window below.



Check Yourself 1

What is the simulated value of Vo?

Vo = 2.0V

$$\frac{1}{R_1} = \frac{1}{2R} + \frac{1}{R}$$
$$V_0 = \frac{R}{R+R} \cdot \frac{R_1}{R_1+R} \cdot V_i$$

Check Yourself 2

Calculate Vo using circuit theory.

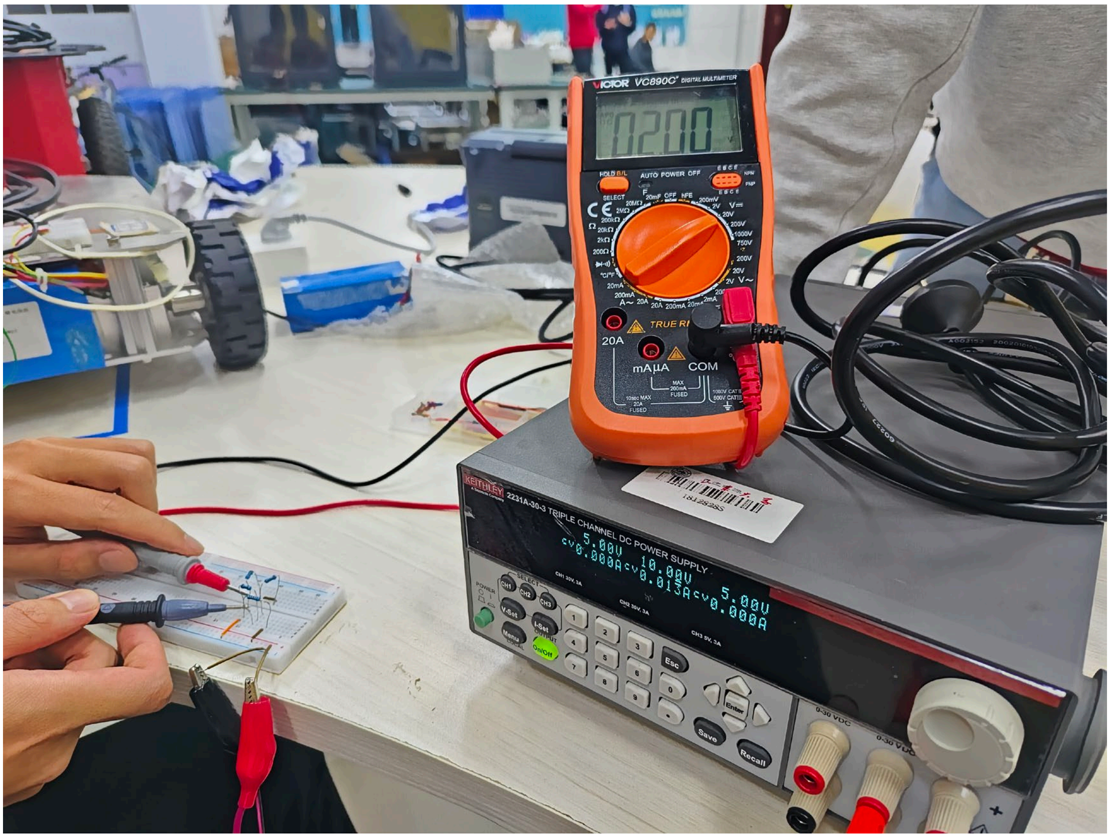
Vo = 2.0V

Compare your result to that of the simulation.

They are the same

Step 8:Lay out the circuit with physical parts.

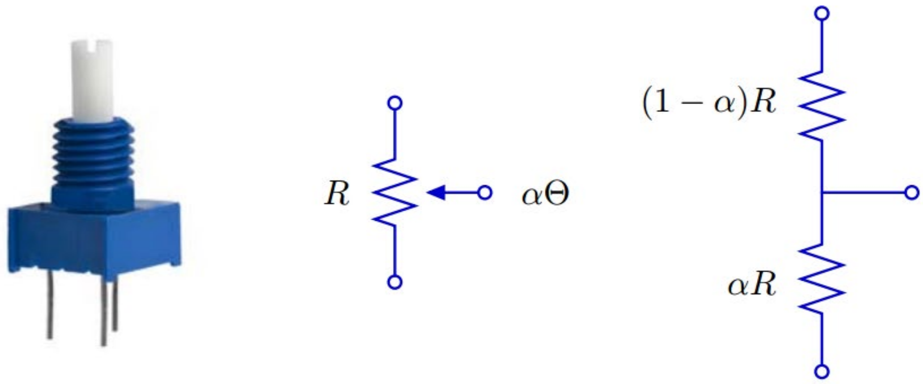
We measure Vo with a multimeter and get the same voltage Vo as simulated one



According to the step above, we found that a voltage divider with equal resistors produces an output voltage that is half the value of the input voltage. However, two voltage dividers connected in cascade do not produce an output that is one quarter of the input voltage. That is because in the actual situation, the second voltage divider will have a loading effect on the first voltage divider. For the reason the second voltage divider has an input resistance, it will form a voltage - dividing relationship with the output resistance of the first voltage divider.

Step 9: Connect the Potentiometer

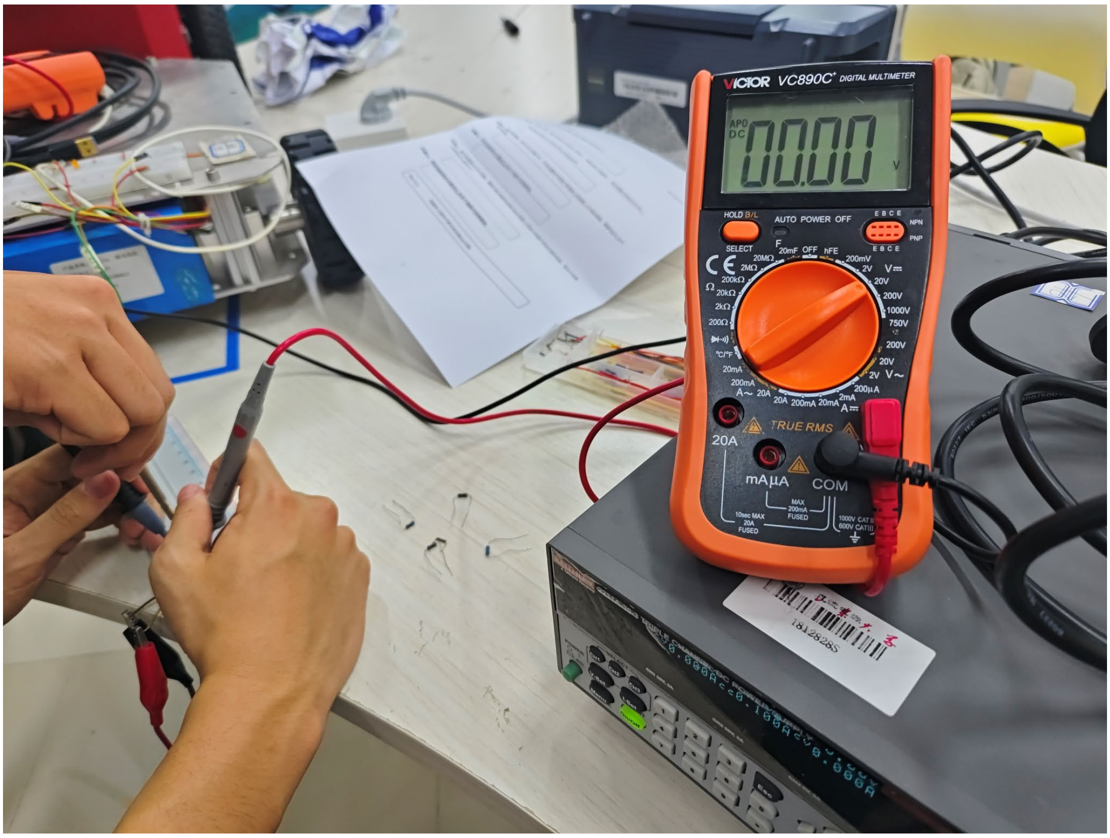
A potentiometer (pot) is a three-terminal device whose electrical properties vary with the angle of its mechanical shaft. The angle (θ) of the input shaft determines the resistance between the terminals, with the sum of the top and bottom resistors remaining constant. For our purposes, we will treat the potentiometer as a primitive element. When connected as a voltage divider (top terminal to a voltage source and bottom terminal to ground), the voltage at the middle terminal is proportional to the shaft angle. The pots provided in the lab have a total resistance of 5KΩ.



Potentiometer diagram

Wire a potentiometer to a 10V supply and ground on the protoboard, connecting power and ground to the two leads at the base of the triangle.

We can notice that the min and max voltages at the middle terminal of the potentiometer are 0V and 10V.


VICTOR VC890C DIGITAL MULTIMETER
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HOLD B/L
AUTO POWER OFF
TRUE RMS
20A
mAµA
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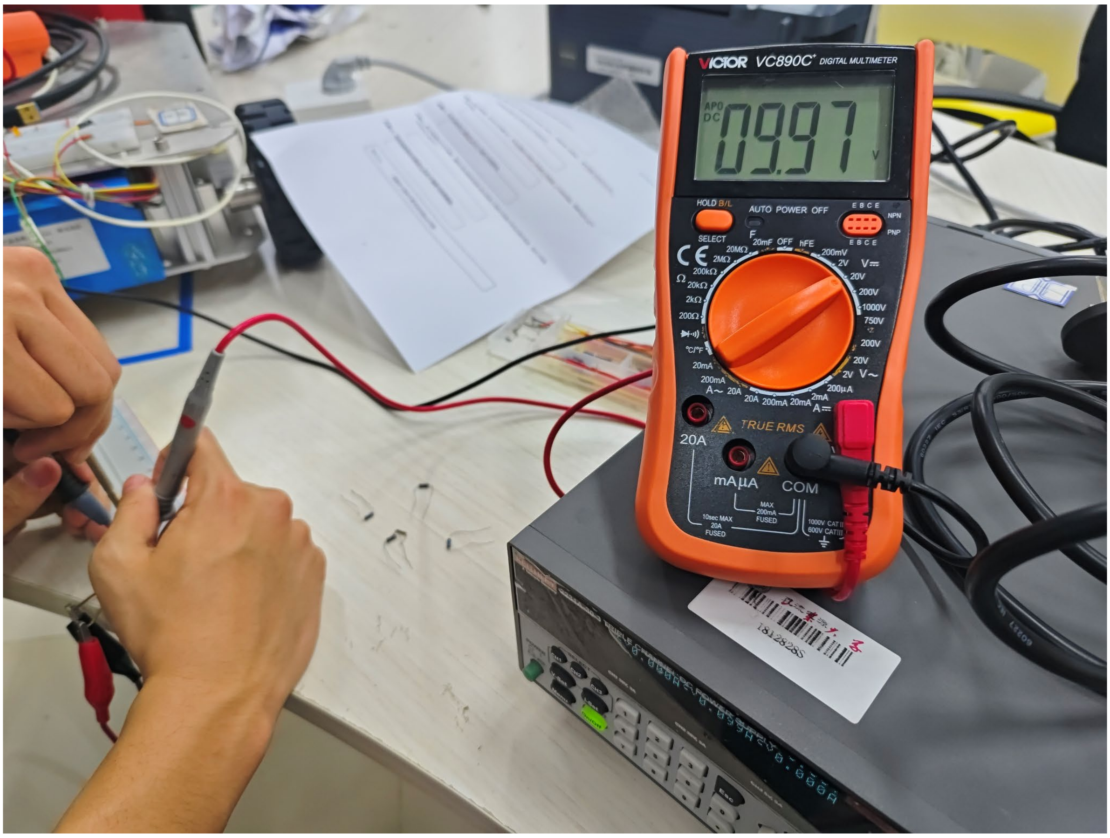

VICTOR VC890C DIGITAL MULTIMETER
09.97
HOLD B/L
AUTO POWER OFF
TRUE RMS
20A
mAµA
COM

Step 10: Adjust the Pot

Adjust the potentiometer so that the voltage on the middle terminal is 2.0V. The corresponding α is 0.2.

Step 11: Measure the Voltage

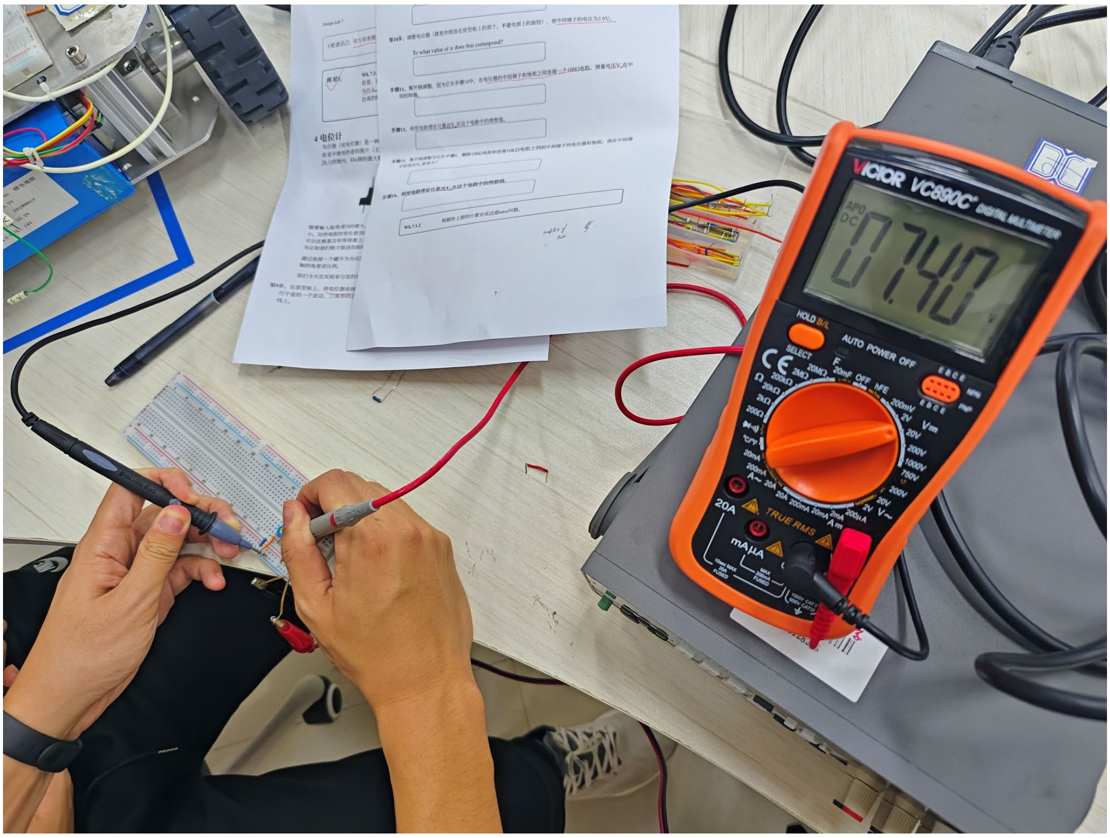
Attach a 100Ω resistor between the middle terminal of the potentiometer and ground. The voltage Vo at the middle terminal is 0.23V.

Step 12: Calculate the Voltage

By using circuit theory, we can compute the ideal value (when the total R equal $5k\Omega$) of V_o in this circuit is $222mV$.

Step 13: Measure the Voltage

Remove the 100Ω resistor and attach a 10KΩ resistor between the middle terminal of the potentiometer and ground. The voltage Vo at the middle terminal is 1.88V.



Step 14: Calculate the Voltage

By using circuit theory, we can compute the ideal value of Vo in this circuit is 1.85V.

Step 15: Resistance value of photoresistor

The relevant values are as follows.

	Left	Right
ambient light	100kΩ	100kΩ
one foot in front of lamp	10kΩ	10kΩ
three feet in front of lamp	90kΩ	90kΩ

Step 16: Design a circuit

From the voltage division characteristics of the resistor, we can obtain:

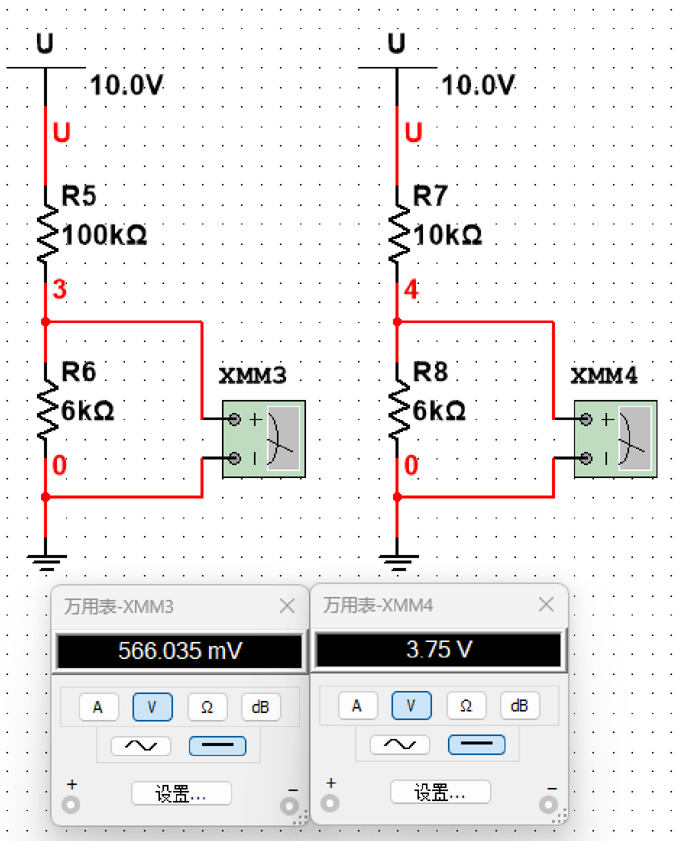
$\frac{UR_2}{R_{bright}+R_2} - \frac{UR_2}{R_{ambient}+R_2} \geq 3V$ where $U = 10V$、$R_{bright} = 10k\Omega$、$R_{ambient} = 100k\Omega$.

Then we calculated that $R_{2min} \approx 5.6k\Omega$.

We have chosen $R_2 = 6k\Omega$

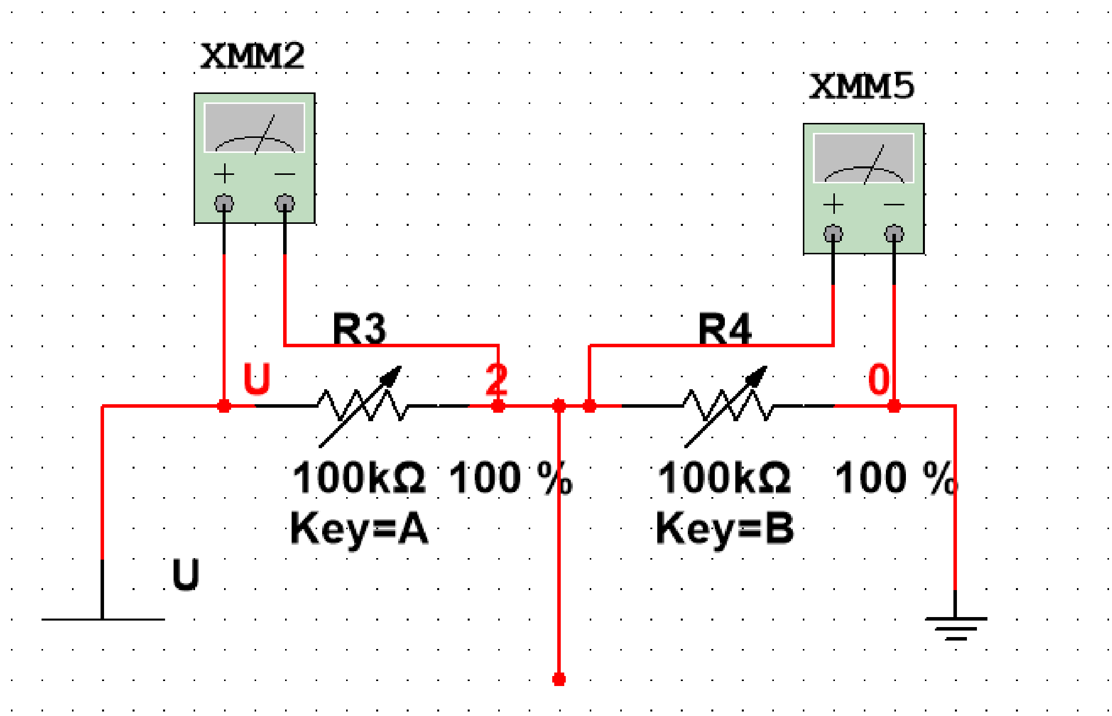
According to the simulation, the voltages we obtained are $V_{ambient} \approx 0.566V$ and $V_{bright} \approx 3.750V$ respectively.

Then we calculated that the voltage change was: $\triangle V = V_{bright} - V_{ambient} = 3.750V - 0.566V = 3.184V > 3V$



	Left	Right
ambient light	0.566V	0.566V
one foot in front of lamp	3.75V	3.75V
three feet in front of lamp	0.625V	0.625V

Draw a schematic for two photoresistor circuits as follows, one to generate the voltage VL from the left photoresistor and one to generate the voltage VR from the right photoresistor, using pins 4, 5, and 6 on the head connector.



Check Yourself 4

Explain how your circuit generates a low voltage under ambient conditions and a higher voltage under bright conditions.

<u>In general, it is about the photoresistor and a fixed resistor competing for a voltage of 10V.</u>

<u>Under low light conditions, the photoresistor has a higher resistance and more voltage division, resulting in a lower output voltage.</u>

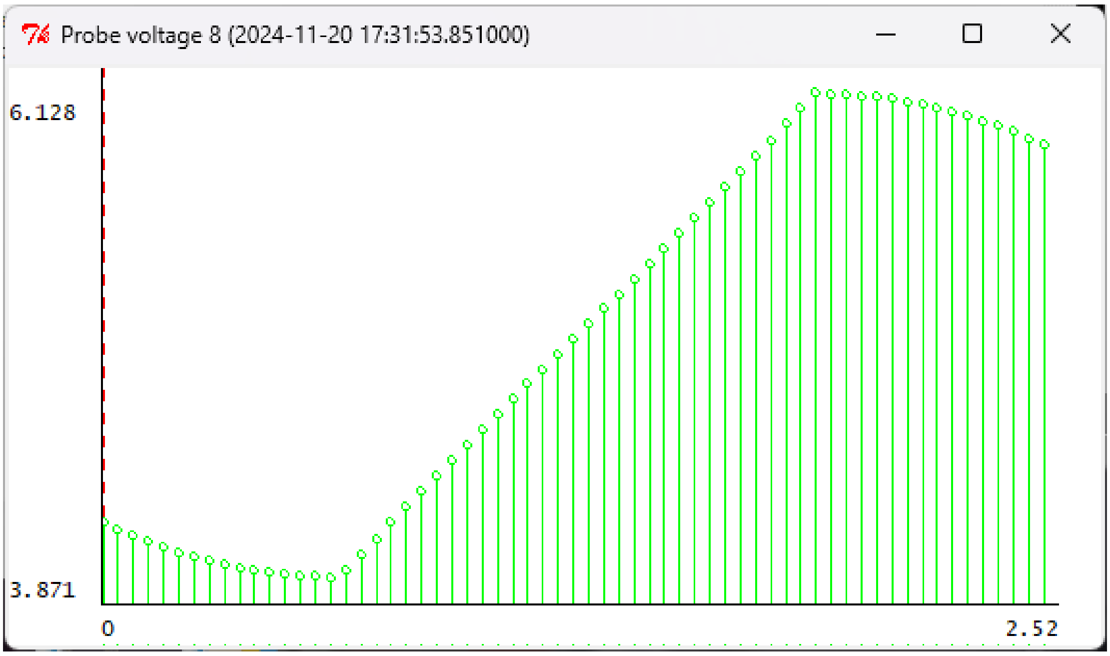
<u>Under bright conditions, the resistance of the photoresistor decreases, resulting in less voltage division and an increase in output voltage.</u>

Step 17: Generate the Plot

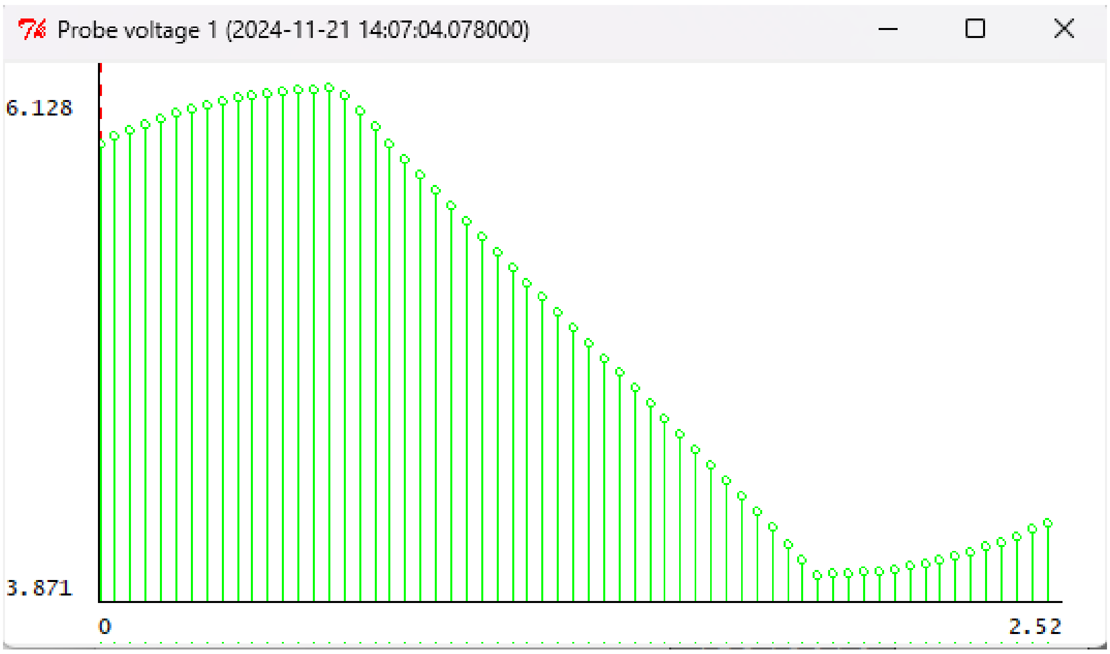
Check Yourself 5

How should each of the measured voltages change as the light moves from left to right? Make sure your plots reflect this. Save each of your plots as a screenshot.

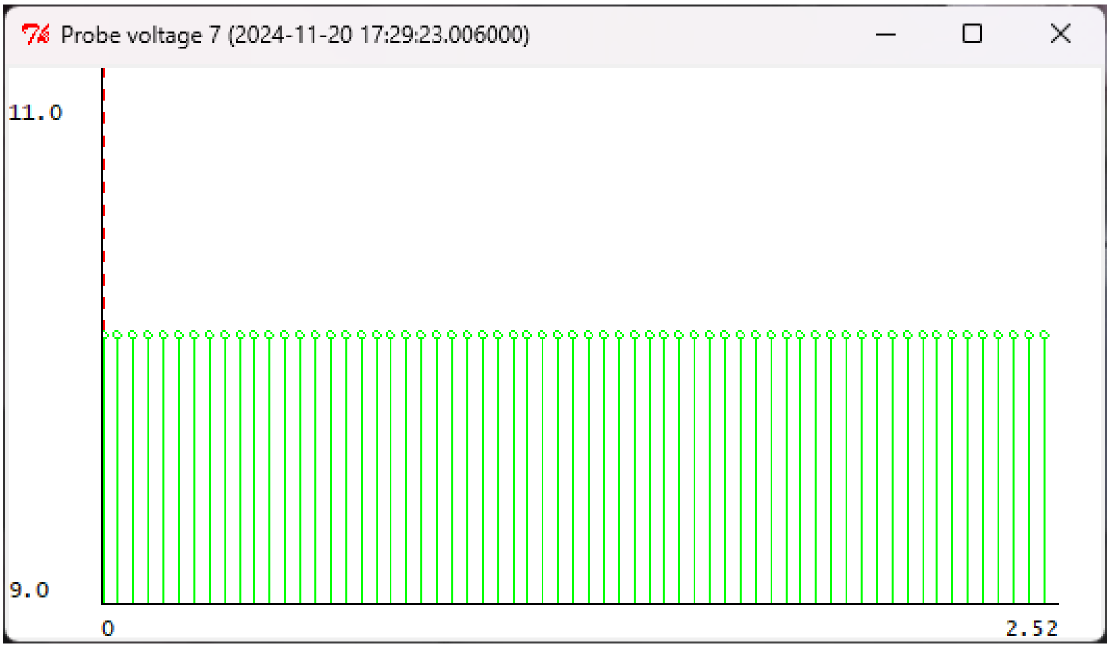
The resistance on the left decreases and then increases, while on the right it is the opposite



Left one



Right one



Total

Step 18: Connecting the Robot and Circuit

1. **Setup the Robot Connector**: Plug a second 8-pin connector into your proto board, referred to as the robot connector.
2. **Connect Power and Ground**: Connect power and ground on your board to the corresponding pins (pins 2 and 4) on the robot connector.
3. **Build the Circuits**: Build the circuits designed in previous steps.
4. **Attach the Head**: Attach the head to the Lego plate on the front of the robot.
5. **Connect the Yellow Cable**: Connect the yellow robot cable to your board and turn on the robot.
6. **Verify Voltages**: Use a multimeter to ensure reasonable values for (V_R) and (V_L). Use your finger to obscure each sensor and check the voltages.

Step 19: Connecting Analog Inputs

1. **Connect (VL) and (VR)**: Connect (VL) to analog input #2 (pin 3) and (R) to analog input #3 (pin 5) on the robot connector.
2. **Understand A-to-D Converters**: These pins connect to A-to-D converters within the robot, making your circuit an added component of the robot.

Step 20: Running the Robot with Light

1. **Setup the Lamp**: Place a standing lamp near the robot or move the robot near a lamp.

2. **Connect and Power On**: Ensure the head/circuit is connected to the robot and turn it on.
3. **Start Soar**: Start Soar and select the `eyeDataBrain.py` brain.
4. **Position the Robot**: Line up the robot in front of the lamp, about a meter away, and manually turn the robot clockwise by 90 degrees.
5. **Run the Rotation**: Click Start in Soar to turn the robot through 180 degrees and click Stop when the rotation is complete.
6. **Save Plots**: Three plots should appear showing the brightness on the left and right eyes and the difference between them. Save these plots as screenshots.

Step 21: Developing a Light-Tracking Strategy

1. **Analyze Plots**: Determine a strategy for making the robot turn toward the light regardless of the initial angle.
2. **Consider Angle Effects**: Think about how the angle affects the light on each photoresistor.
3. **Formulate Strategy**: Develop a strategy based on the plots of (VL) and (VR) as a function of angle

3. Summary

- The experiment aimed to simulate and construct circuits for a robot "head" that tracks light using light sensors, voltage dividers, and potentiometers. The focus was on understanding basic circuit components and their applications.
- Adjustments to the potentiometer demonstrated its functionality in controlling voltage output, with calculations and measurements verifying the impact of resistance changes on circuit behavior.
- Simulated and real measurements were consistent, confirming that theoretical predictions matched practical outcomes, especially for voltage divider circuits under specific configurations.